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Editorial

Noninvasive medical diagnoses based on body dissipation

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Recent research conducted with the use of thermal imaging techniques has revealed the diversity of applications for infrared thermal imaging and its successful implementation in medicine. With the explosion of Infrared thermal imagers on the market for all types of applications, the medical or health care area remains very specific with its requirements for obtaining high resolution and consistent thermograms at space and time domain. Imaging environment controls, patient or subject preparation, capturing capabilities, technician training, and image processing features are all factors to be considered in application of an infrared thermal imaging system. The new multidimensional and multispectral (visible 0.4–0.8 μm and IR up to 14 μm) open perspective technical predispositions to improve and define the exact new noninvasive and preventive *green health imaging technology*.

The total amount of radiation coming from human body is determined very simply from the surface temperature of body and the surface area by the Stefan-Boltzman Law which says that the total energy radiated by a blackbody per unit area per unit time is sigma*T^4, where sigma is the Stefan-Boltzman constant, 5.67E-8 J K^{-4} m^{-2} s^{-1}, and T is the temperature in kelvins. So if we have a surface area of 1 m^2 and a surface temperature of 310 K, then the body radiates at a rate of a little over 450 Watts. This means that we need to eat over 9 000 Calories (1 kCal=4.184 kJ) per day just to maintain the body temperature.

To establish the energy balance the body is constantly absorbing radiation as well as emitting it. Anyway, the absolute rate at which the body radiates is in the neighborhood of 450 W. Any energy generated by the body is eventually radiated or the body temperature rises (simple thermodynamics). We can also attempt to measure every single adenosine triphosphate and other chemical reaction in the body but, overall, calories consumed or absorbed = calories radiated or expelled, otherwise the temperature goes up.

Body heat must be dissipated at the balance with the metabolic heat production. The body has several adjustment mechanisms for the protection of the deep-body temperature. If the environment is too cold, vasoconstriction reduces heat transport from deep tissues to skin surface, skin temperature is thus lowered and heat dissipation rate is reduced. Further adjustment can be provided by shivering: an involuntarily increased metabolic heat production. If on the other hand the environment is too warm so that heat dissipation is restricted, vasodilation increases heat transport to the surface and elevates skin temperature, thereby increasing the heat dissipation rate.

Body muscle movement must generate heat if it uses energy which must be radiated or otherwise expelled or exchanged via conduction. At rest, the human body gives off nearly 1600 calories per minute. During active periods, the thermal output jumps to about 2900 calories per minute.

When resting, about 78 percent of the heat is given off by normal heat transfer processes such as conduction, convection, and radiation. 22 percent is given off by evaporation of perspiration. While working, 45 percent of the heat is lost by normal heat transfer methods and 44 percent through perspiration. The remaining 11 percent goes toward the actual accomplishment of physical work. Calculations based on these numbers indicate that the human being is approximately 11 percent efficient.

The brain makes up 2% of a person's weight. Despite this, even at rest, the brain consumes 20% of the body's energy. The brain consumes energy at 10 times the rate of the rest of the body per gram of tissue. The average power consumption of a typical adult is 100 watts and the brain consumes 20% of this, making the power of the brain 20 W. Glucose is the main energy source for the brain. As the size and complexity of the brain increases, energy requirements increase. The human brain is one of the most energy hungry organs in the body, which increases its vulnerability. If the energy supply is cut off for 10 minutes, there is permanent brain damage. There is no other organ nearly as sensitive to changes in its energy supply.
Blood flow plays an important role in the regulation of normal body temperature because blood contains a large volume of water which is an excellent heat conductor. When the body becomes higher and activates the heat losing center (the hypothalamus), impulses are sent to the sweat glands of the skin, and these sweat glands produce perspiration. Perspiration evaporates from the surface of the skin and the skin is cooled. About 80 to 95 % of body heat is lost through the skin. Another two ways in which the body dissipates the heat energy are through urination and elimination of feces. For all this body temperature regulation mechanism responsible the hypothalamus which control of body heat production and control of body heat loss.

A full and correct diagnosis of tissue or organ damage should be carried out considering both dimensional, visible chromatic, and thermal parameters. A great variety of methods have been proposed with the aim of producing objective assessment of many indications but none of the existing technologies seem to be robust enough to work for relevant indications. This paper describes an innovative and non-invasive system that allows the automatic measurement of body dissipations. Infrared thermography, also known as thermal imaging, can provide accurate, nondestructive information about the thermal envelope performance of any 3D objects. This includes validation of structural details, verification of energy distribution performance and system analyses. The methodology involves the integration of a three-dimensional (3D) optical scanner, based on a structured light approach, with a thermal imager. The system enables the acquisition of geometrical data which are directly related to chromatic and temperature patterns through a mapping procedure. Organ dissipation areas are detected by combining visible and thermal imaging. This approach allows for the automatic measurement of the extension and depth of thermal processes, even in the absence of significant and well-defined chromatic patterns. The proposed technology has been tested in the measurement of many indications and you can find the results in this special issue. Clinical tests have demonstrated the effectiveness of this methodology in supporting medical experts in the assessment of many new diagnostic indications.

In dynamic thermography, thermal transients are additionally studied. Such approach allows imaging and visualization of body subsurface abnormalities or diseases and has already gained high recognition in medical diagnoses or monitoring of healing processes. Research and clinical applications of multidimensional dynamic thermography performed in this special issue open new noninvasive diagnostic possibilities taking into account its applicability, resolution, detectability, data analyses and reconstruction methods and especially taking into account the limited number of practical applications published up to now.

All the above shows that temperature changes in various parts of the (body in spatial and temporal characteristics) have an expression in different functional states of the organism. The ability to create many high resolution data via multidimensional dynamic thermography (4D thermography) opens new possibilities in medical diagnostics based on the analysis of dissipation of thermal energy of the body. In this respect, this special issue gives an integrated view of the state of the art, depicting new possibilities in the use of thermography in medicine.